

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

RECONNAISSANCE GEOLOGIC MAP OF THE COLUMBIA RIVER
BASALT GROUP, NORTHERN OREGON AND WESTERN IDAHO

by

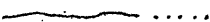

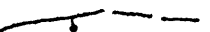

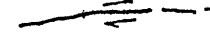
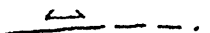
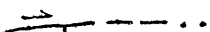
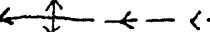
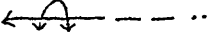
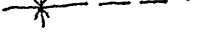











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This report is preliminary
and has not been edited or
reviewed for conformity with
Geological Survey standards

EXPLANATION

	Contact, approximately located; dotted where concealed
	Fault, dashed where approximately located; dotted where concealed
	High-angle fault; bar and ball on downthrown side
	Thrust fault; sawteeth on upper plate
	Strike-slip fault, showing relative horizontal movement
	Strike-slip fault, sense of relative horizontal movement indeterminate
	Oblique-slip fault, showing relative horizontal and vertical movement
	Fold, showing direction of plunge if any; dashed where approximately located; dotted where concealed
	Crestline of upright anticline
	Crestline of overturned anticline
	Troughline of syncline
	Monocline, dashed where approximately located; dotted where concealed
	Abrupt decrease of dip in direction of arrows
	Abrupt increase of dip in direction of arrows
	Prominent photo or topographic lineament, possibly a strike-slip fault
	Attitude
	Strike and dip
	Horizontal
	Overtaken
	Vent area with map symbol of unit in vent
	Dike with map symbol of unit fed by dike

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DESCRIPTION OF MAP UNITS

- Qs SEDIMENTARY DEPOSITS--Alluvium, morainal and glacial outwash material, and gravel, sand and silt deposited by Missoula floods. Locally includes loess of Palouse Formation. More extensive than shown; generally mapped only where important bedrock relations are obscured
- Qls LANDSLIDE DEPOSITS--Poorly sorted chaotic deposits, generally with hummocky topography. Mostly along contact of poorly lithified or clay-rich sediments and overlying flows of Grande Ronde or Wanapum Basalt. Includes deposits of block slides
- Qba ANDESITE AND BASALT--Flows, cinder, and small intrusive bodies of olivine basalt and andesite erupted in the Cascade Range, chiefly from Mount Hood (Wise, 1968, 1969; White, 1980) and the King Mountain and Indian Heaven fissure zones in Washington (Hammond and others, 1976). Mostly younger than about 700,000 yrs (Hammond and others, 1976).
- Qts LOESS AND ASSOCIATED FLUVIAL DEPOSITS--Mostly loess of Palouse Formation, but locally includes interbedded and underlying fine sand, silt, and stream gravel. More extensive than shown; mapped only where important bedrock relations are obscured. Mostly Pleistocene

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QTg GRAVEL AND CONGLOMERATE--Unconsolidated and weakly consolidated gravel, interbedded sand, and tuffaceous deposits. Composed mostly of clasts derived from Columbia River Basalt Group and older units. Includes deposits of the Shutler formation of Hodge (1932, 1942) and "Pliocene fanglomerate" of Hogenson (1964), both correlated with the Dalles Formation by Newcomb (1966). Includes terrace gravel near Ukiah (T. 5 S., R. 31 E.) and auriferous gravel of mixed lithology near Starkey (T. 3-4 S., R. 35-36 E.). In Richland basin, lower part of unit is dominantly tuffaceous (similar to unit Tsev) and of lacustrine origin (Brooks and others, 1976)

QTb OLIVINE BASALT-- Principally olivine basalt flows and cinder in Cascade Range (Hammond, 1980; Hammond and others, 1980) and Simcoe Mountains volcanic area (Sheppard, 1967; Sylvester, 1978). Mostly Pliocene, but in large areas of Oregon Cascade Range includes rocks of Pleistocene age. Potassium-argon dates for flows in Goldendale area range from about 0.9 to 4.5 m.y. (Kienle and others, 1979), and for rocks in the upper Clackamas River area from about 0.25 to 4.2 m.y. (Sutter, 1978; Hammond and others, 1980). Locally includes flows, tuffs, and small intrusive bodies of andesitic, dacitic, and rhyolitic compositions (Sheppard, 1967)

YAKIMA BASALT SUBGROUP OF COLUMBIA RIVER BASALT GROUP--See Swanson and others (1979) for more complete descriptions of most units

SADDLE MOUNTAINS BASALT--Includes:

- Tb Buford Member--Basalt flow overlying sedimentary deposits resting on Umatilla Member near Flora, Oregon. Includes Buford flow of Walker (1973b). Rests on Elephant Mountain Member a short distance north of map area. Contains sparse small plagioclase phenocrysts. Generally less than 20 m thick. Buford chemical type (Wright and others, 1980). Reversed magnetic polarity. Feeder dike occurs in Joseph Creek drainage 15 km southeast of Flora
- Tem Elephant Mountain Member--Nearly aphyric basalt flows of Elephant Mountain chemical type (Wright and others, 1973). Normal to transitional magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). Potassium-argon age about 10.5 m.y. (McKee and others, 1977). Occurs extensively on the Horse Heaven Plateau, Washington, and between Arlington and Boardman, Oregon. Includes the Wenaha flow of Walker (1973b) in and south of the lower Wenaha River area (Ross, 1978). Feeder dike occurs upriver from confluence of Wenaha and Grande Ronde Rivers (Ross, 1978; 1980, fig. 3)
- Tcg Basalt of Craigmont--Fine- to medium-grained basalt flow with scattered plagioclase phenocrysts as long as 10 mm.

Chemically distinct from most other flows in Columbia River Basalt Group (V. E. Camp, unpub. data, 1979; Wright and others, 1980). Normal magnetic polarity. Occurs just north of Grangeville, Idaho. Upper age limit unknown. Two north-northeast trending feeder dikes occur along Slate Creek, about 35 km south of Grangeville

Tgv Basalt of Grangeville--Medium- to coarse-grained basalt flow with sparse plagioclase phenocrysts less than 7 mm long and abundant, commonly altered, olivine phenocrysts and microphenocrysts. Bears some resemblance chemically to Pomona and Dodge chemical types (V. E. Camp, unpub. data, 1979; Wright and others, 1980). Reversed magnetic polarity. Occurs near Grangeville, Idaho and in scattered outcrops farther west. Feeder dike occurs in Rocky Canyon (T. 30 N., R. 1 E.) west of Grangeville. Equivalent to the Amphitheater flow of Bard (1978)

Tp Pomona Member--Slightly phyric basalt flow of Pomona chemical type (Wright and others, 1973). Contains small phenocrysts of plagioclase, clinopyroxene, and olivine. Reversed magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). Potassium-argon age about 12 m.y. (McKee and others, 1977). Occurs extensively on Horse Heaven Plateau and in northern Oregon along Columbia River. Locally occurs as intracanyon flow west of Hood River, Oregon (Anderson, 1980).

- Twe Basalt of Weippe--Medium- to coarse-grained flow of Pomona chemical type. Reversed magnetic polarity. Petrographically similar and probably equivalent to Pomona Member, but mapped separately because the easternmost outcrops of the Pomona, in the Lewiston basin, are 35 km west of the westernmost outcrops of the basalt of Weippe (Swanson and others, 1979).
- Tan Andesite-- Fine-grained, commonly platy, light to dark gray andesite erupted from local centers northeast of Baker, such as Sawtooth Ridge (Patterson, 1969; Brooks and others, 1976), and flanking Grande Ronde Valley near La Grande. Small phenocrysts of plagioclase and hornblende common. Rocks within unit have wide range of chemical compositions, with SiO_2 contents from 50 to 66 wgt percent (Wright and others, 1980). Those rocks with less than about 58 percent SiO_2 may be fractionated basalt; no adequate name for rocks of these compositions exists. Unit commonly forms hills above gently-dipping basalt flows. Potassium-argon ages for andesite at Sugarloaf, Spring, and Wilbur Mountains west of Grande Ronde Valley are about 7 m.y. (Kienle and others, 1979). Potassium-argon ages for andesite just east of Grande Ronde Valley are older, between about 9 and 12 m.y. (E. H. McKee and W. H.

Taubeneck, written commun., 1979). Informally included in Columbia River Basalt Group; later work may result in excluding unit from the group

- Tfg Basalt of Ferguson Spring--Fine-grained, aphyric flow with very high P_2O_5 content (P. R. Hooper, unpub. data, 1978). Occurs only as a small remnant capping tuffaceous deposit east of Grande Ronde River in T. 4 N., R. 41 E., about 22 km north of Minam, Oregon. Normal magnetic polarity
- Tslk Basalt of Sprague Lake--Sparsely plagioclase-phyric dike and flow at vent area about 7 km west of Riggins, Idaho. Chemically similar to the basalt of Sprague Lake in eastern Washington (Swanson and others, 1979); Wright and others, 1980). Normal magnetic polarity. Correlation with basalt of Sprague Lake tentative
- Ta Asotin Member--Sparsely plagioclase- and olivine-phyric, commonly ophitic basalt flow of Asotin chemical type (Camp, 1976; Wright and others, 1980). Normal magnetic polarity. Occurs extensively in Clearwater embayment east of Lewiston, Idaho, but in mapped area crops out only 15-20 km northeast of Grangeville
- Tawg Asotin Member and basalts of Weippe and Grangeville, Shown only where map scale and steep topography prohibit separation

- T1a Basalt of Lapwai--Fine- to medium-grained, sparsely plagioclase-phyric flow assigned to the Wilbur Creek Member but with higher MgO and lower SiO_2 than rest of member (Swanson and others, 1979; Wright and others, 1980). Chemically intermediate between Wilbur Creek and Asotin chemical types (Wright and others, 1980). Contains rare small plagioclase and olivine phenocrysts. Occurs extensively in Clearwater embayment but found in mapped area only within 15-20 km northeast of Grangeville, Idaho.
- Ten Basalt of Eden--Fine- to medium-grained, plagioclase- and olivine-phyric basalt flow or flows. Plagioclase phenocrysts as much as 6 mm long, and olivine phenocrysts about 3 mm across. Distinctive chemical composition, characterized by about 1.2 wgt percent P_2O_5 (Ross, 1978; Wright and others, 1980). Normal magnetic polarity. Occurs in Akers Butte-Howard Butte area north of Minam, Oregon, farther north in the Elbow Creek area, and farther west near Fry Meadows Guard Station. Feeder dike crosses Grande Ronde River in T. 4-5 N., R. 41 E. Commonly exhibits complex invasive relations with tuffaceous sedimentary deposits (Ross, 1978). Unit and associated sedimentary deposits are confined southeast of a major northeast-trending fault, which may have controlled site of deposition

- Tens Basalt of Eden and tuffaceous sedimentary deposits,
undivided--Mapped only where invasive relations are
complex and exposures poor owing to landsliding and
forest cover
- Tu Umatilla Member--Fine-grained basalt flow or flows of Umatilla
chemical type (Wright and others, 1980) and its older
variant, the Sopher Ridge chemical type (P. R. Hooper,
unpub. data, 1979; Wright and others, 1980). Typified
by very even grain size and near lack of phenocrysts.
Normal magnetic polarity (Rietman, 1966). Includes
Bear Creek flow of Ross (1978), probably equivalent to
the flow of Sopher Ridge type. Occurs on Horse Heaven
Plateau, along Columbia River east of Umatilla,
Oregon, at scattered localities on northwest flank of
Blue Mountains uplift east of Adams, Oregon, and
extensively between crest of uplift and Joseph Creek.
Commonly overlain by tuffaceous sedimentary deposit in
Grande Ronde River drainage area. Major vent area
occurs just north of mapped area at Puffer Butte
(Price, 1974, 1977; Swanson and others, 1980), and
feeder dikes occur along strike in mapped area in
Joseph Creek (T. 6 N., R. 45 E.) and in Little Sheep
Creek (T. 1 S., R. 47 E.; Kleck, 1975)

WANAPUM BASALT--Includes:

- Tpr Priest Rapids Member--Fine- to coarse-grained basalt flows of Rosalia and Lolo chemical types (Wright and others, 1980) with reversed magnetic polarity (Rietman, 1966). Flows of Rosalia chemical type are nearly aphyric and contain groundmass olivine visible with hand lens in fine-grained samples. Flows of Lolo chemical type generally contain phenocrysts of olivine and commonly plagioclase. Flows of Lolo chemical type consistently overlie flows of Rosalia chemical type on Horse Heaven Plateau and farther west. Flows of Rosalia chemical type occur north of Slate Creek (T. 31 N., R. 4 and 5 E.) and along north edge of mapped area east of Grangeville; flows of Lolo type dominate farther north in Clearwater embayment. Feeder dikes of Lolo chemical type occur along Slate Creek, forming the southernmost known part of a linear vent system possibly 160 km long containing dikes of both chemical types
- Tr Roza Member--Basalt flows of Roza chemical type (Wright and others, 1973) that consistently contain several percent single, in places clotted, plagioclase phenocrysts averaging nearly 10 mm across and evenly distributed throughout most flows. Transitional or reversed

magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). Very extensive unit elsewhere on Columbia Plateau (Swanson and others, 1979, 1980), but in mapped area occurs only in three small outcrops along Crow Creek, Oregon (T. 2 N., R. 45 E.). Feeder dikes occur along Joseph Creek (T. 5 N., R. 45 E.) (Price, 1977), farther south along the creek (T. 4 N., R. 45 E.), and at confluence of Crow and Chesnimnus Creeks (T. 3 N., R. 45 E.). These dikes form the southern part of a linear vent system at least 160 km long (Swanson and others, 1975).

Tob Olivine basalt--Diktytaxitic, commonly olivine- and plagioclase-phyric basalt flows. Characterized by relatively high MgO (about 8 wgt percent) and Al_2O_3 (16.5-17 wgt percent) and low K_2O (0.5-0.6 wgt percent) (Wright and others, 1980). Easily recognized in field because of diktytaxitic texture. Overlies basalt of Powatka and underlies Umatilla Member; age relative to Roza and Priest Rapids Members unknown. Thin tuffaceous sedimentary deposits commonly underlie and overlie unit

Tpo Basalt of Powatka--Fine-grained, aphyric basalt flow lacking distinguishing physical characteristics but identifiable by its chemical composition (Wright and

others, 1980) and general stratigraphic position. Characterized by P_2O_5 content of about 1 wgt percent (Ross, 1978; Wright and others, 1980). Occurs on east flank of Blue Mountains uplift, north of Grande Ronde Valley, and in Troy basin, where it was first recognized by Ross (1978). Normal magnetic polarity

Tf Frenchman Springs Member--Basalt flows of Frenchman Springs chemical type (Wright and others, 1973). Many flows contain irregularly distributed plagioclase glomerocrysts as much as 50 mm across, but some flows, particularly the younger ones, are virtually aphyric. Generally fine- to medium-grained. Normal magnetic polarity (Rietman, 1966). Overlies thin saprolite developed on top of Grande Ronde Basalt in places in Blue Mountains, and commonly rests on thin tuffaceous or subarkosic sandstone and siltstone farther west. Basal flow is pillowed in many places. Unit can be subdivided into several recognizable flows throughout much of area; these flows were not mapped separately, but their identification helped to define structural relations. Very extensive in western part of mapped area and in Blue Mountains north of Umatilla River. Not recognized east of Troy basin. Feeder dikes occur in north-northwest zone 20-25 km wide extending from lat. $45^{\circ} 30'$ north of La Grande to north edge of

mapped area and far beyond (Swanson and others, 1979, 1980). Dikes are subvertical in most places but dip about 20 degrees east in a zone south of Milton-Freewater and about 20 degrees west in a zone from Pikes Peak south to Tollgate. One gently dipping dike may occur in Vansycle Canyon (T. 5 N., R. 33 E.)

- Tpf Basalt of Powatka and Frenchman Springs Member, undivided--Mapped only where topography and scale preclude separation
- Tek Basalt of Lookingglass--Fine-grained, aphyric basalt flow with distinctive chemical composition characterized by "intermediate" P_2O_5 content of about 0.65 wgt percent (Wright and others, 1980). Overlain by Frenchman Springs Member and underlain by basalt of Dodge (Eckler Mountain Member). Occurs only in upper reaches of North Fork of Umatilla River, South Fork of Walla Walla River, and in Lookingglass Creek drainage. Normal magnetic polarity
- Tpk Basalts of Powatka and Lookingglass, undivided--Mapped only where topography and scale preclude separation
- Eckler Mountain Member--Petrographically and chemically distinctive basalt flows between basalt of Lookingglass and Grande Ronde Basalt. Saprolite generally underlies and locally overlies unit. Normal magnetic polarity. Subdivided into three map units:
- Tes Basalt of Shumaker Creek--Fine-grained, nearly aphyric basalt younger than basalt of Dodge and older than Roza Member. Crops out as flow north of mapped area

(Swanson and others, 1980), but in area occurs only as dikes along Chesnimnus Creek (T. 3 and 4 N., R. 45 E.) and about 90 km farther south-southeast along North Pine Creek (T. 7 S., R. 47 E.). Similar chemically to basalt of Lookingglass but distinguished by having lower TiO_2 (2.4 vs. 2.7 wgt percent) and higher P_2O_5 (0.8 vs. 0.65 wgt percent)

Ted

Basalt of Dodge--Coarse-grained, moderately to highly plagioclase-phyric basalt flows in Blue Mountains north of South Fork Walla Walla River and in Wenaha and Grande Ronde River drainages. Abundant olivine altered to clay minerals, commonly causing rock to break down to grus during mechanical weathering. Generally two flows present, the lower being more highly phyric than the upper. Along Wenaha and Grande Ronde Rivers, commonly forms reddish-brown rounded cliffs. Chemically distinctive except for similarity to some very high MgO flows of Grande Ronde Basalt (Wright and others, 1980). Interbedded with Frenchman Springs Member on east side of South Fork Walla Walla River (sec. 32, T. 5 N., R. 39 E.), but in other places in mapped area underlies the Frenchman Springs. Feeder dikes of similar composition and hand specimen appearance occur in T. 6 and 2 N., R. 41 E. and T. 6, 5, and 4 N., R. 43 E. Dikes with similar chemistry but considerably fewer plagioclase

phenocrysts in T. 6 and 5 N., R. 45 E., T. 6 N., R. 46 E., and T. 2 S., R. 46 E. included within unit but may be feeders for high MgO flows of Grande Ronde Basalt

Ter Basalt of Robinette Mountain--Aphyric diktytaxitic olivine basalt flow with abundant olivine partly altered to iridescent iddingsite. Chemically distinctive by its high MgO (about 8 wgt percent), CaO (11 wgt percent), and Al_2O_3 (17 wgt percent) contents; distinguished chemically from basalt of unit Tob by lower K_2O (about .3 vs .5 wgt percent). Occurs in small exposures within 3 km east and west of confluence of North and South Forks of Wenaha River (T. 5 and 6 N., R. 40 E.). Collapsed pahoehoe (Swanson and others, 1975) occurs in these exposures, suggesting nearby vent. Feeder dikes define linear trend through outcrop area, from Beaver Creek (T. 6 N., R. 40 E.) south for 7 km to South Fork Wenaha River, and another dike occurs along this trend in Minam River (T. 2 N., R. 41 E.), about 35 km farther south. This linear trend continues for 18 km northward in Washington (Swanson and others, 1980)

Tkd Basalts of Lookingglass and Dodge, undivided--Mapped only where topography and scale preclude separation

Tpd Basalt of Powatka, Frenchman Springs Member, and basalt of Dodge, undivided--Mapped only where topography and scale preclude separation

- Tpkd Basalt of Powatka, Frenchman Springs Member, and basalts of Lookingglass and Dodge, undivided--Mapped only where topography and scale preclude separation
- Tsm Dikes of unknown affinity, probably Saddle Mountains or Wanapum Basalt--Occur along Joseph Creek, in Imnaha River drainage, and on lower Salmon River (T. 30 N., R. 3 and 4 W). Chemical compositions differ from those of known flows. Most have similarities to Asotin chemical type but have higher TiO_2 content (1.60-1.85 vs. less than 1.50 wgt percent); some of Price's (1977) "Pomona dikes" have this composition. Includes Kleck's (1975) "Haas Ridge dikes" and Price's (1977) dike J 6, which show similarities to Lolo and Sprague Lake chemical types. Tentatively considered to be of Wanapum or Saddle Mountains age, although youngest stratigraphic unit cut by dikes is lower Grande Ronde Basalt (unit Tgn₁)
- Twr Basalt of Windy Ridge--Flow beneath basalt of Grangeville and above Grande Ronde Basalt (unit Tgr₂) on Windy Ridge north of confluence of Wolf Creek and Snake River (T. 29 N., R. 2 W.). Similar chemically to most dikes in unit Tsm but higher in TiO_2 (2.20 vs. 1.00-1.85 wgt percent). Includes dike in Getta Creek (T. 28 N., R. 2 W.; Kleck, 1977, no. WO-80) and one along strike at Pittsburgh Landing along Snake River (T. 2 N., R. 51 E.)

Tgo

Basalt of Powder River--Sequence of olivine-bearing, commonly

olivine-phyric, basalt flows in Baker Valley-Lower Powder Valley area, and in isolated exposures near Sawtooth Ridge (T. 7 S., R. 42 and 43 E.). Dominantly reversed magnetic polarity near Baker Valley and normal polarity farther east. Chiefly high- Al_2O_3 basalt, with MgO contents from 5 to 9 wgt percent and low K_2O (0.2 to 0.9 wgt percent) and TiO_2 (0.7 to 1.6 wgt percent) contents. Severely faulted. Inadequately mapped. Overlies Grande Ronde Basalt (unit Tgn₁) and underlies andesite at Sawtooth Ridge. Chemically resembles olivine basalt flows in units Tob and Ter. South of Baker flows appear to have erupted from cinder cones. Includes flow rich in P_2O_5 (0.95 wgt percent) capping Sparta Butte (T. 8 S., R. 44 E.). Flows southwest of Baker Valley laterally continuous into Strawberry Volcanics of Brown and Thayer (1966). Questionably included in Columbia River Basalt Group; further work may exclude unit from group

GRANDE RONDE BASALT--Basalt flows, aphyric to very sparsely

plagioclase-phyric, comprising thickest and most voluminous formation in Columbia River Basalt Group. Generally fine-grained and petrographically non-distinctive. A few flows in lower reversely magnetized part of section (R₁ of Swanson and

others, 1979) contain numerous plagioclase phenocrysts. Chemical composition varies within a broad field now termed Grande Ronde chemical type (Yakima chemical type of Wright and others, 1973). In western part of mapped area, flows of high-Mg Grande Ronde chemical type generally overlie somewhat finer-grained, hackly flows of low-Mg type in upper normally magnetized (N_2) part of section. Flows range in thickness from less than 1 m to more than 50 m but are generally between 15 and 25 m. Many flows near margin of Columbia Plateau are invasive into interbedded subarkosic sediments, forming sill-like bodies as much as 120 m thick. Covers and laps out on rugged topography developed on older rocks around margins of Columbia Plateau, where flows are commonly pillowed. In some places flows undergo a facies change near the margin of the plateau, thickening and becoming hackly jointed within a few kilometers of the margin, with a pillowed zone at or very close to contact with the older rocks. Divided into magnetostratigraphic units on basis of dominant magnetic polarity:

Tgn_2 Upper flows of normal magnetic polarity--Magnetostratigraphic unit N_2 . Thins eastward and pinches out at about long.

117° 15', except for isolated remnants associated with vent areas west of Imnaha River

- Tgr₂** Upper flows of reversed magnetic polarity--Magnetostatigraphic unit R₂. Thins eastward and pinches out at about long. 116° 30', except for isolated patches farther east
- Tgn₁** Lower flows of normal magnetic polarity-- Magnetostatigraphic unit N₁. Identification of unit along Grande Ronde River west of La Grande, and along Birch Creek southeast of Pilot Rock questionable; flows in these areas could represent a normal polarity interval within unit R₂, as suggested by stratigraphic thicknesses of R₂ in nearby areas
- Tgr₁** Lower flows of reversed magnetic polarity--Magnetostatigraphic unit R₁. Occurs only in eastern part of mapped area. Overlies either Imnaha Basalt or older nonbasaltic rocks
- Tgd** Feeder dikes for flows of Grande Ronde Basalt--Mostly 3-6 m wide. Correlated with Grande Ronde Basalt on basis of chemical composition. Dominantly feeders for units Tgn₂ and Tgr₂. Dikes occur throughout mapped area east of long. 118° 15'. Feeder dike and associated vent areas for flows in unit Tgr₂ found along Lone Rock Creek (T. 5 S., R. 23 E.). Mapped dikes most highly concentrated along Joseph Creek (T. 5 and 6 N., R. 45 and 46 E.)